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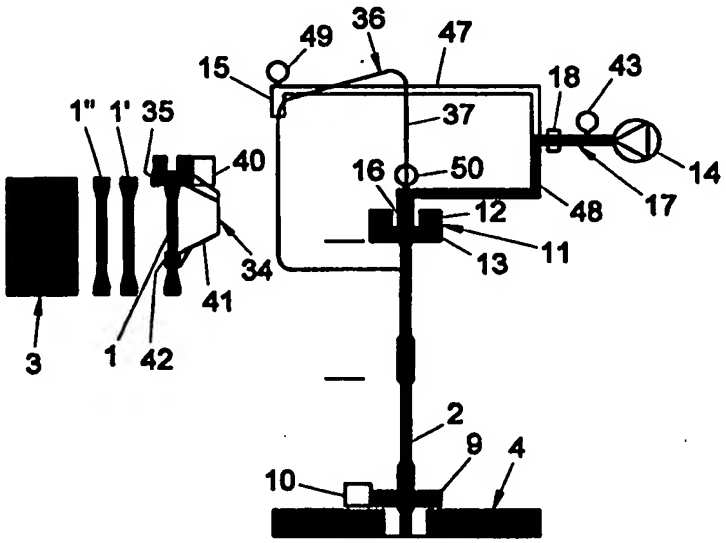
(54) Title: MUD CIRCULATION FOR LITHOSPHERE DRILLING

(57) Abstract

Mud is fed to a distal end of the string (2) in a bore hole in the earth. Each time the string (2) has been displaced into the litosphere over a predetermined distance, a connecting cycle is started. This cycle includes the steps of: connecting one mud head (15, 16) of a mud circulation structure to a pipe section (1) to be connected; disconnecting another mud head (15, 16) from the pipe string (2); and subsequently connecting the pipe section (1) connected to the mud head (15, 16) to the pipe string (2). During a next connection cycle, the other mud head (15, 16) is connected to a next pipe section (1) to be connected. The time during which the mud structure is disconnected from the pipe string (2) is substantially reduced. A device for carrying out that method and a drilling rig including such a device are also described.



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Title: Mud circulation for lithosphere drilling.

TECHNICAL FIELD

The invention relates to the introduction of a pipe string including serially connected pipe sections in a lithosphere bore hole involving circulation of mud through the pipe string. Such operations occur for instance in the course of drilling or lining oil or gas wells.

BACKGROUND ART

Drilling for oil or gas and lining of the well typically involves the introduction of a large number of pipe sections or stands such as drill pipe sections and casing pipe sections into the well. The sections are each time connected to a pipe string composed of sections projecting into the well after having been brought into line with the pipe string. Each section may be formed by a single joint or by a plurality of joints which have been connected to each other before being connected to the pipe string.

During drilling the pipe string is typically rotated while mud is being fed to the pipe string for instance to drive a mud motor connected to a drill bit at the extreme end of the pipe string and/or, as a lubricant, to facilitate introduction of the pipe string into the bore hole. It is also known to circulate mud during introduction of a drill string in a previously bored hole (tripping) and during introduction of a casing string to wash down the casing string.

Couplings between the pipe string and pipe sections to be added to the pipe string are typically made by screwing the pipe sections onto the pipe string each time the pipe string has been introduced into the bore hole over a predetermined distance corresponding to the length of a previously added pipe section.

The efficiency and effectivity of such operations is substantially impaired by the interruptions of the mud flow required to connect or disconnect the next section. This is of particular importance because the drilling of a bore hole typically involves a plurality of tripping operations (extracting and re-introducing the pipe string) for inspection or replacement of the drill bit. Each tripping operation includes the disconnection and connection of about 50-300 sections. More specifically, stopping the mud flow has various adverse effects such as gelation of mud in the bore hole and an increase of the risk of the pipe string getting stuck in the bore hole.

SUMMARY OF THE INVENTION

It is an object of the present invention to reduce the time of interruption of the mud flow during connection of pipe string sections to the pipe string.

According to the present invention, this object is achieved by providing a method for introducing a pipe string into a bore hole in the lithosphere, in which mud is fed via a mud circulation structure to a trailing end of the pipe string and canalised through the pipe string to a leading end of the pipe string as the pipe string is fed into the bore hole, wherein, each time the pipe string has been displaced into the lithosphere over a predetermined distance, a connecting cycle is started. This connecting cycle includes the steps of: connecting one mud head of the mud circulation structure to a pipe section to be connected; disconnecting another mud head of the mud circulation structure from the pipe string; and subsequently connecting the pipe section connected to the mud head to the pipe string. A next connection cycle includes the step of connecting the other mud head to a next pipe section to be connected to the pipe string.

Another embodiment of the invention for achieving this object is formed by a mud circulation structure for circulating mud to a pipe string projecting into a bore hole in the lithosphere, including: a mud pump, at least two mud heads, at least one conduit for directing mud from the mud pump to and through each of the mud heads, and means for shutting off the mud flow conduit for alternately directing the mud flow through each one of the mud heads.

By connecting another mud head of the mud circulation structure to a pipe section to be connected, the time during which the mud circulation structure is disconnected from the pipe string can be reduced substantially. In turn, this facilitates restarting of the mud circulation and reduces friction and wear if the pipe string is rotated continuously during connection of a pipe section as well. Preferably, the other mud head is connected to the pipe section to be connected before the mud head on the trailing end of the pipe string has been removed.

The reduction of the time needed to change over the coupling of the mud circulation structure from the pipe string to a next pipe section connected to the pipe string makes the provision of a mud flow during tripping advantageous in a much wider range of situations, so that for instance the number of times that gas or oil swap occurs can be reduced.

A particular embodiment of the invention is formed by a drilling rig for lithosphere drilling including a mud circulation structure as described above, a structure for moving a pipe string along a pipe string axis and a mud head guide structure for guiding the mud heads along a circulating path including a section co-axial with the pipe string axis. As a mud head is guided along the section of the circulating path which is co-axial with the pipe string axis, a top end of a newly connected pipe section can be guided until it is engaged by a pipe section engaging structure. It is noted

that the mud heads can in principle also be guided for movement to and fro between ends of separate paths.

Another particular embodiment of the invention is formed by a drilling rig for lithosphere drilling including a mud circulation structure as described above and a pipe string drive unit for driving rotation of a pipe string axially projecting into a bore hole in the lithosphere, which pipe string drive unit includes: a pipe string engagement structure for circumferentially engaging the pipe string; and a pipe string drive including a drive motor operatively coupled to the pipe string engagement structure and to a rotationally fixed support structure for driving rotation of the pipe string engagement structure. The pipe string drive unit has a continuous passage for receiving a portion of the pipe string. Thus, a pipe string engaged by the pipe string drive unit is accessible at its proximal end for co-operation with a mud head of the mud circulation structure.

Further objects, modes, embodiments and details of the invention appear from the dependent claims and the description in which reference is made to the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figs. 1-6 are schematic side views representing successive stages of the method according to the invention;

Fig. 7 is cross-sectional side view of a mud buffer storage; and

Fig. 8 is a cross-sectional side view of another mud buffer storage.

MODES FOR CARRYING OUT THE INVENTION

In Figs. 1-6 a presently most preferred example of a rotary drilling rig for drilling into the lithosphere and more in particular for drilling and lining oil and gas wells is schematically depicted in successive stages of an

operation of adding a pipe section 1 - in this case a single joint pipe section - to a pipe string 2. Further pipe sections 1' and 1'' are stored in a pipe section dispenser 3 aside the pipe string 2.

The drilling rig has a well head 4. Above the well head 4, a rotatable clamp 9 is mounted to a vertically movable, lower drilling table (not shown). In the situation shown in Fig. 1, the pipe string 2 is releasably suspended from the clamp 9. The clamp 9 is connected to a drive 10 for driving rotation of the pipe string 2 with a torque of up to about 15,000 - 25,000 Nm. The design of the clamping section of the clamp 9 can in principle be similar to that of conventional spiders for stationary mounting on a rig floor.

Above the clamp 9 and co-axial therewith, a pipe coupling unit 11 is mounted to an upper drilling table (not shown) which is vertically movable as well. The pipe coupling unit 11 has a pipe section clasping structure 12 for engaging the pipe section 1. The pipe coupling unit 11 is further provided with a pipe string clasping structure 13, for engaging the pipe string 2, which structure 13 is located coaxial with the pipe section clasping structure 12 and in a position axially different from the position of the pipe section clasping structure 12. Thus, the pipe coupling unit 11 also forms a pipe string drive unit. For the sake of conciseness, this unit will however be referred to as pipe coupling unit 11. The designs of the pipe section clasping structure 12 and of the pipe string clasping structure 13 can for instance be essentially identical to that of a known spider or elevator with active power assisted clamping to ensure sufficient traction also if the pipe string is still short and therefore of light weight. Preferably, both clasping structures are capable of transferring a make-up torque of about 50,000 to 120,000 Nm to the respective engaged pipe portions. The pipe section clasping structure 12 should preferably be capable of retaining pipe sections against axial loads of at least 2,500 to 3,000 kg. The pipe

string clasping structure 13 should be able to carry the whole weight of a pipe string suspended in a bore hole, which can be up to about 500,000 kg for a casing string when the string is at its full length.

For rotating the pipe string clasping structure 13 and for rotating the pipe section clasping structure 12 relative to the pipe string clasping structure 13, a pipe string drive and a pipe section drive including drive motors are provided. For an example of these drives, reference is made to applicant's co-pending PCT application entitled "Making and breaking of couplings between pipe sections in a drilling rig", which has the same filing date as the present application.

For circulating mud to a pipe string 2 projecting into a bore hole in the lithosphere, a mud circulating structure is provided, including: a mud pump 14, two mud heads 15, 16, a conduit 17 for directing mud from the mud pump 14 to each of the mud heads 15, 16; and valves 19 (see Fig. 8) for shutting off the mud flow conduit 17 for alternately preventing mud flow through each of the mud heads 15, 16. The valves 19 also form blow-out preventers.

As appears from Fig. 8, the mud head includes a head portion 20 in which a connecting portion 21 is suspended rotatably by a sealed bearing 22. In the head portion a passage leading to a buffer 49 meets the conduit 17.

In operation, adding a pipe section 1 to a pipe string 2 starts with the picking up of a pipe section 1 from the dispenser 3. For this purpose and for transferring pipe sections 1 from the dispenser 3 to the proximal end of the pipe string 2 projecting into a bore hole in the lithosphere and vice versa, a pipe handler 34 is provided. This pipe handler 34 includes a pipe section engagement structure 35 for releasably engaging pipe sections to be transferred. To guide and drive the pipe section engagement structure 35 between a position adjacent the dispenser 3 and a position and orientation in line with the pipe string 2, a lift unit

(not shown) is provided which is guided by vertical guide rails. For further details regarding the lift unit, reference is again made to applicant's co-pending PCT application entitled "Making and breaking of couplings between pipe sections in a drilling rig".

The pipe section handler 34 further includes a drive, schematically depicted by square 40 connected to the pipe section engagement structure 35 for driving rotation of that pipe section engagement structure 35. According to the present example, the pipe section engagement structure 35 and the drive 40 are of essentially the same design as that of a conventional Iron Roughneck. However, the skilled person will appreciate that many other possibilities of driving rotation of the pipe section engagement structure 35 of the pipe section handler 34 are possible.

The pipe section handler 34 further includes a stabilising arm 41 projecting under the pipe section engagement structure 35 and having a gripper 42 adjacent its lower end. This arm 41 prevents substantial pendular motion of a pipe section 1 retained in the pipe section engagement structure 35.

While the pipe section is being transferred from the dispenser 3 to the proximal (in this case upper) end of the pipe string 2, rotation and axial displacement of the pipe string 2 is continued and mud is fed through the conduit 17 and via the mud head 16 connected to the pipe string 2. This is represented by the blackened portion of the conduit 17. In the situation shown in Fig. 1, just after a previous pipe section has been connected, the pipe string 2 is driven by the rotating spider clamp 9 as in the situation shown in Fig. 6. At latest just before the rotating spider clamp 9 has reached the lower end of its range of travel, the drive of the pipe string 2 is taken over by the pipe coupling unit 11, by first engaging the pipe string clasping structure 13 to the pipe string 2 and by releasing the rotating spider clamp 9 from the pipe string 2.

The mud heads 15, 16 are guided by a mud head guide track 36 for guiding the mud heads 15, 16 along a circulating path including a section 37 co-axial with the pipe string axis. The mud head 16 is guided by the vertical portion 37 as the pipe string 2 progresses into the earth.

Just before the clamp 9 has reached its lowest position, the pipe string clasping structure 13 is brought into engagement with the proximal end of the pipe string 2 and takes over the function of driving the pipe string. Subsequently, the lower drill table 5 is returned to its upper take-over position. This position of the clamp 9 is shown in Fig. 2.

Fig. 2 further shows the operation of connecting the mud head 15 to the pipe section 1 to be connected to the string 2. To make the connection between the pipe section 1 and the mud head 15, the pipe section 1 is spun relative to the mud head 15 and thereby screwed to the mud head 15. During a final portion of the rotation of the pipe section 1, the pipe section is driven with a torque up to a predetermined make-up torque.

As is shown in Fig. 3, the pipe coupling unit 11 and the clamp 9 are gradually lowered while the pipe section 1 is transferred to a position in line with the pipe string 2. Then, the mud flow towards the mud head 16 connected to the pipe string 2 is interrupted by closing the valve 19. This is represented in Fig. 3 by the outlined portion of an initially dark portion of the conduit 17. Immediately after the mud flow to the mud head 16 is interrupted, the mud head 16 is disconnected from the pipe string by means of the pipe coupling unit 11.

In the meantime, as shown in Fig. 4, the pipe section 1 has reached a position in line with the pipe string 2, but still remote thereof. The mud head 16 is being removed from between the pipe section 1 and the pipe string 2, so that the pipe section 1 can be connected to the pipe string 2.

In the meantime, the pipe section 1 to be coupled to the pipe string 2 has been accelerated by the drive 40 to substantially the same rotational velocity as the rotational velocity of the pipe string 2 and the pipe section 1 is lowered until its lower coupling end is introduced into the pipe section clasping structure 12 (Fig. 5). When the pipe section 1 has reached its desired level, the pipe section clasping structure 12 is operated to engage the pipe section 1 and the pipe section engagement structure 35 of the pipe handler is released from the pipe section 1. Subsequently, the pipe coupling unit rotates the pipe section 1 relative to the pipe string 2 to make the connection between these parts 1, 2.

After the connection has been made, the rotating spider clamp 9 is brought into engagement with the pipe string 2 and takes over the function of driving and carrying the pipe string 2 from the pipe coupling unit 11, and the mud flow through the mud head is started immediately. Because it is not necessary to move the removed mud head to the free end of the connected pipe string and to connect that mud head before the mud flow can be restarted, the downtime of the mud flow at each connection can be reduced substantially. In particular if the pipe string is rotated continuously, the reduced downtime of the mud flow while an additional pipe section is being connected thereto, substantially reduces wear and disturbances of mechanical and hydrodynamic equilibrium in the bore hole.

Subsequently, as is shown in Fig. 6, the pipe handler 34 is moved away from the pipe string 2 in a direction radial to the string 2. The pipe coupling unit 11 is moved upward along the added pipe section 1.

As the pipe coupling unit 11 and the pipe handler 34 move upward, the uppermost pipe section of the pipe string is guided by the mud head 15 attached to the newly connected pipe section 1, which mud head 15 is, in turn, guided by the

vertical portion 37 of the circulating guide track 36 for guiding the mud heads 15, 16.

It is observed that in the present example the pipe string is oriented vertically, but that the pipe string can also be oriented in a slanting or even horizontal orientation.

In practice, if a mud pump 14 is stopped, it takes several minutes after a restart until the pump 14 is operating at its optimum level. This problem is avoided by continuous operation of the mud pump 14. Mud fed by the mud pump can for instance be returned to the mud pump via a return conduit.

In the present example, a mud buffer storage 43 is provided downstream of the mud pump 14. Because mud supplied by the mud pump 14 is buffered between the pump 14 and the mud head or mud heads in a time interval between disconnection of one of the mud heads 15, 16 from the string 2 and connection of the pipe section 1 connected to the other one of the mud heads 16, 15 to the string 2, a volume of mud is collected which is pressed through the conduit immediately after the connection between the conduit 17 and the string is re-established. Thus, a quicker build-up of mud circulation is obtained after interruption of the mud circulation.

The mud buffer storage 43 is provided with a mud storage chamber 44 and a chamber 45 filled with nitrogen or another suitable gas. The chambers are separated by a membrane 46. While the mud supply structure is disconnected from the string 2, the mud storage chamber 44 expands and is filled with mud against the pressure of the gas in the chamber 45. As soon as the connection between the conduit 17 and the string 2 is re-established, the gas presses the stored mud out of the chamber buffer 43, so that the output of the mud circulation structure is temporarily boosted.

In the chambers 43, 44, support baffles 54, 55 with grids of passages are provided to support the membrane 46 in its extreme end conditions.

The conduit 17 has two conduit branches 47, 48, each directing to one of said mud heads 15, 16. This provides a simple and effective connection between the mud heads 15, 16 and the mud pump 14.

The mud circulation structure further includes two mud buffer storages 49, 50 (Figs. 1-6 and 8), each communicating with one of the branches 47, 48 closely upstream of the shut-off valves at the mud heads 15, 16. Like the mud buffer storage 43, these two mud buffer storages 49, 50 each include a mud chamber 51 and a gas-filled chamber 52 separated from the mud chamber 51 by a membrane 53. Baffles 56, 57 are mounted in the chambers 51, 53 to limit deformation of the membrane 52.

In operation, mud is alternately fed via one and the other of the mud heads 15, 16. In a first operating condition, mud is fed towards and buffered near said first mud head 15 while mud is being fed via the other mud head 16. In a second, alternative operating condition, mud is fed towards and buffered near the other mud head 16 while mud is being fed via the first mud head 15. The main purpose of these buffer storages 49, 50 is to dampen shut-off and release shocks in the mud circulation structure when the valves 19 in the mud heads 15, 16 are opened or closed. Buffering in buffer storages communicating with the branches 47, 48 furthermore provides the advantage that a quick boosting effect is achieved because little pressure is lost between the buffer and the mud head and little mud has to be accelerated after the valve 19 has been opened to restart the mud flow through the respective mud head 15, 16.

It will be readily apparent to the skilled person that, although the above examples relate to the drilling and lining of oil and gas wells, accordingly adapted modes of carrying out the present invention can also be used in connection with other ground drilling operations.

Claims

1. A method for introducing a pipe string (2) into a bore hole in the lithosphere, in which mud is fed via a mud circulation structure to a proximal end of the pipe string (2) and canalised through the pipe string (2) to a distal end of the pipe string (2) as the pipe string (2) is fed into the bore hole, wherein, each time the pipe string (2) has been displaced into the lithosphere over a predetermined distance, a connecting cycle is started, said connecting cycle including the steps of:

connecting one mud head (15, 16) of the mud circulation structure to a pipe section (1) to be connected;

disconnecting another mud head (16, 15) of the mud circulation structure from the pipe string (2); and

subsequently connecting said pipe section (1) connected to said mud head (15, 16) to the pipe string (2);

a next connection cycle including the step of connecting said other mud head (16, 15) to a next pipe section (1) to be connected to the pipe string (2).

2. A method according to claim 1, wherein a mud pump (14) of the mud circulation structure is continuously active.

3. A method according to claim 2, wherein mud supplied by said mud pump (14) is buffered between said pump (14) and at least one of said mud heads (15, 16) in a time interval between disconnection of one of said mud heads (15, 16) from the pipe string (2) and connection of said pipe section (1) connected to the other one of said mud heads (16, 15) to the pipe string (2).

4. A method according to claim 3, wherein mud is alternately fed via one and the other of said mud heads (15, 16), and wherein, in a first operating condition, mud is fed towards and buffered near said one mud head (15, 16) while mud is being fed via said other mud head (16, 15) and wherein, in a second, alternative operating condition, mud is

fed towards and buffered near said other mud head (16, 15) while mud is being fed via said one mud head (15, 16).

5. A method according to any one of the preceding claims, wherein said pipe string (2) is continuously rotated.

6. A mud circulation structure for circulating mud to a pipe string (2) projecting into a bore hole in the lithosphere, including:

a mud pump (14);

at least two mud heads (15, 16);

at least one conduit (17) for directing mud from the mud pump (14) to and through each of said mud heads (15, 16); and

means for shutting off said mud flow conduit (17) for alternately directing the mud flow through each one of said mud heads (15, 16).

7. A mud circulation structure according to claim 6, further including at least one mud buffer storage (43, 49, 50) downstream of said mud pump (14).

8. A mud circulation structure according to claim 6 or 7, in which said at least one mud buffer storage (43, 49, 50) includes a mud chamber (44, 51) and a resilient structure (45, 46, 52, 53) for exerting a resilient return pressure counteracting expansion of the mud chamber (44, 51).

9. A mud circulation structure according to any one of claim 6-8, further including at least two conduit branches (47, 48), each directing to one of said mud heads (15, 16).

10. A mud circulation structure according to claim 9, further including at least two mud buffer storages (49, 50), each communicating with one of said branches.

11. A drilling rig for lithosphere drilling including a mud circulation structure according to any one of claims 7-10, means for moving a pipe string (2) along a pipe string axis and a mud head guide structure (36) for guiding each of said mud heads (15, 16) along a path including a section (37) co-axial with said pipe string axis.

12. A drilling rig for lithosphere drilling including a mud circulation structure according to any one of claims 7-10 and

a pipe string drive unit for driving rotation of a pipe string (2) axially projecting into a bore hole in the lithosphere, said pipe string drive unit (11) comprising:

a pipe string engagement structure (13) for circumferentially engaging the pipe string (2); and

a pipe string drive including a drive motor operatively coupled to said pipe string engagement structure (13) for driving rotation of said pipe string engagement structure (13),

said pipe string drive unit (11) having a continuous passage for receiving a portion of said pipe string (2).

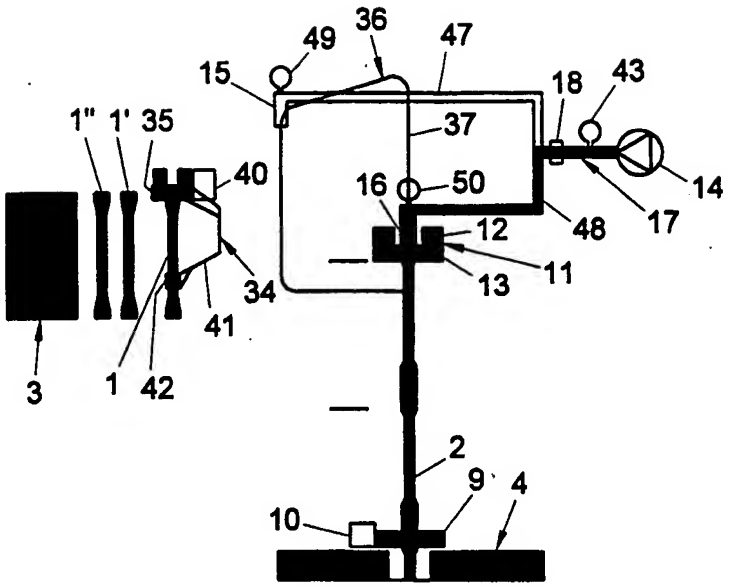
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Fig. 1

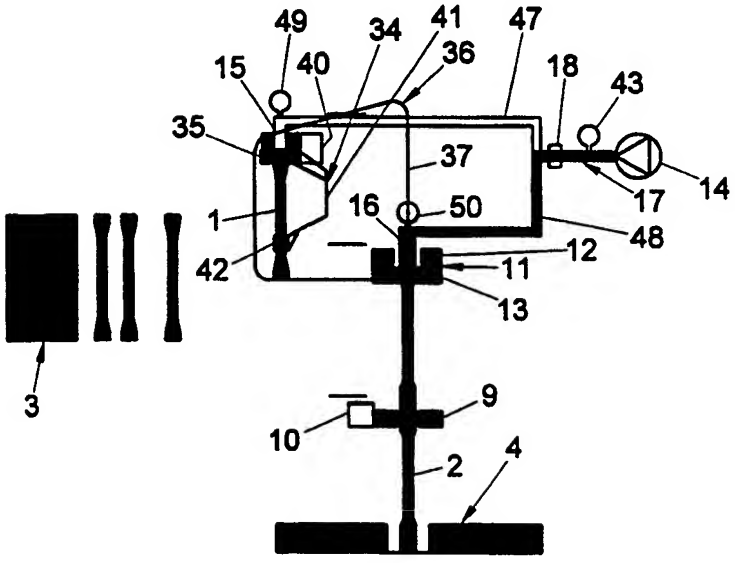
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Fig. 2

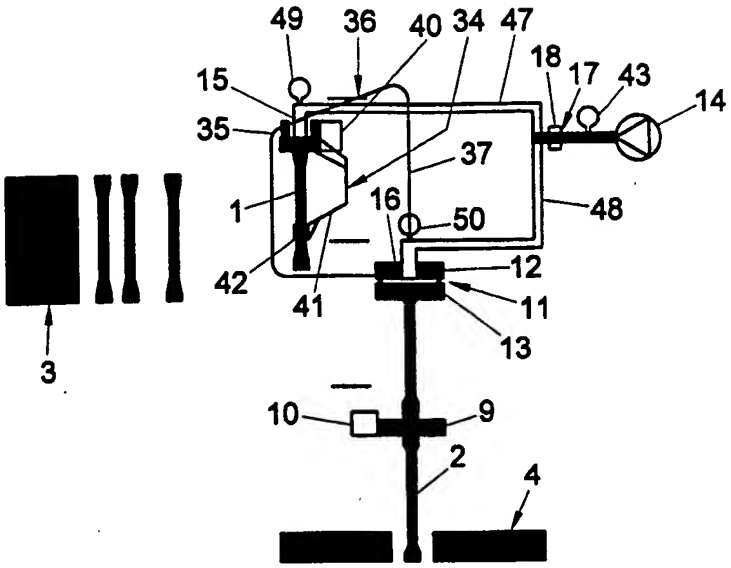
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Fig. 3

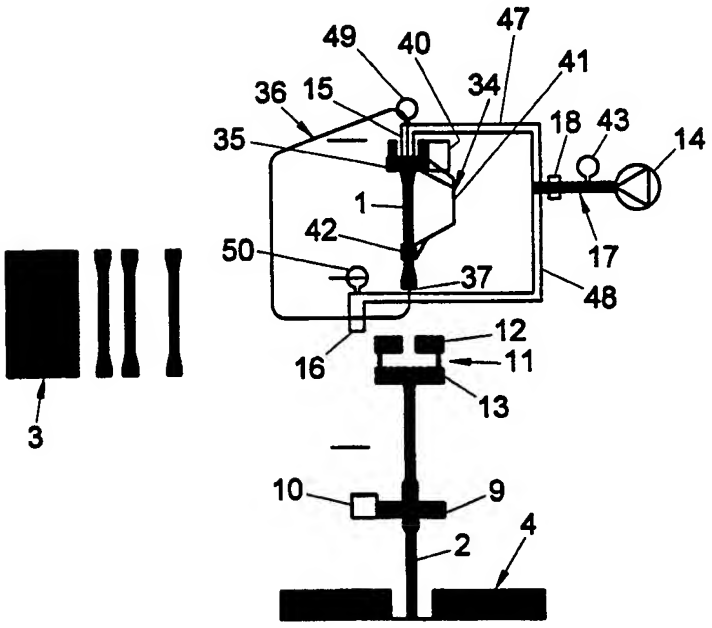
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Fig. 4

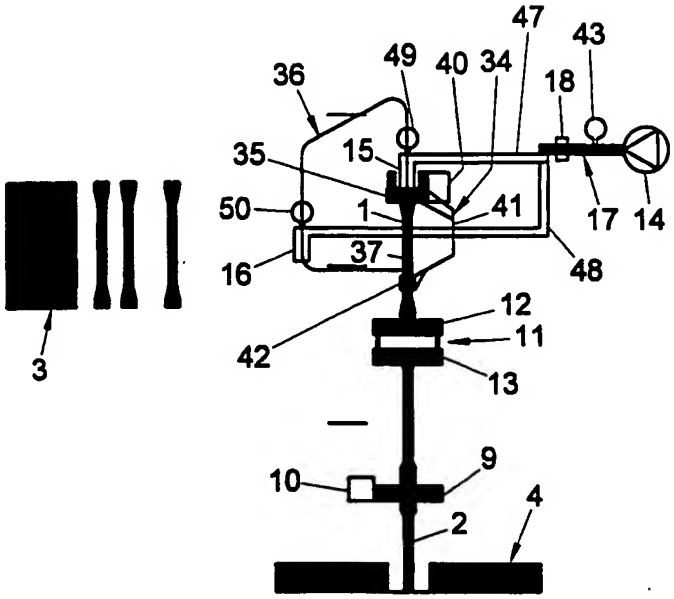
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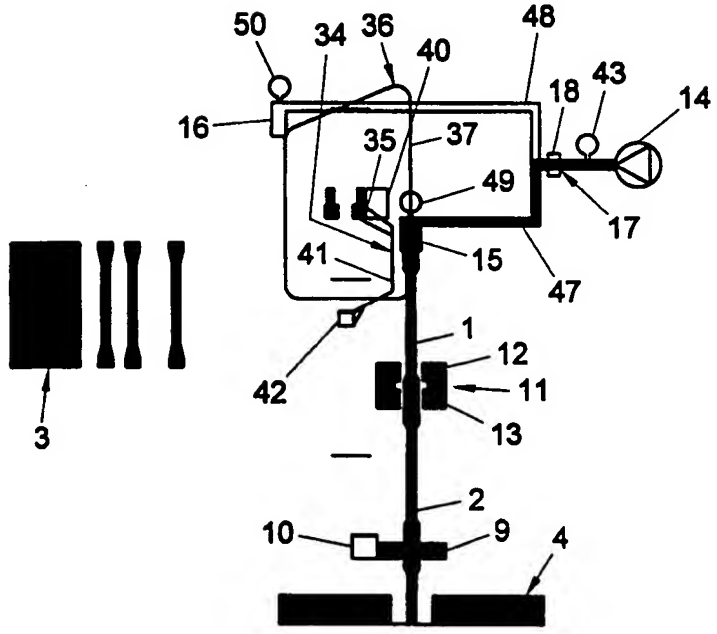
Fig. 5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14
16
35
37
49
17
41
15
47
1
12
42
11
13
3
2
10
9
4

Fig. 6

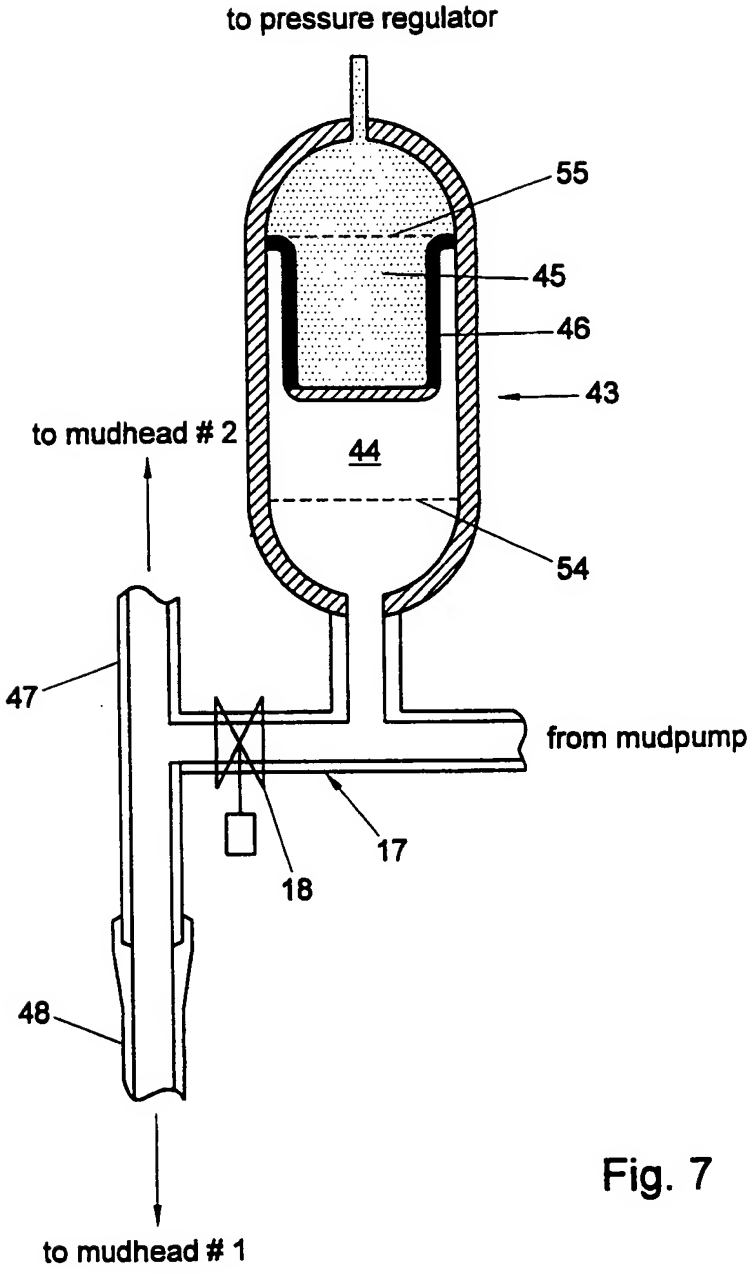
to pressure regulator
55
45
46
43
to mudhead # 2
44
54
47
from mudpump
17
18
48
to mudhead # 1

Fig. 7

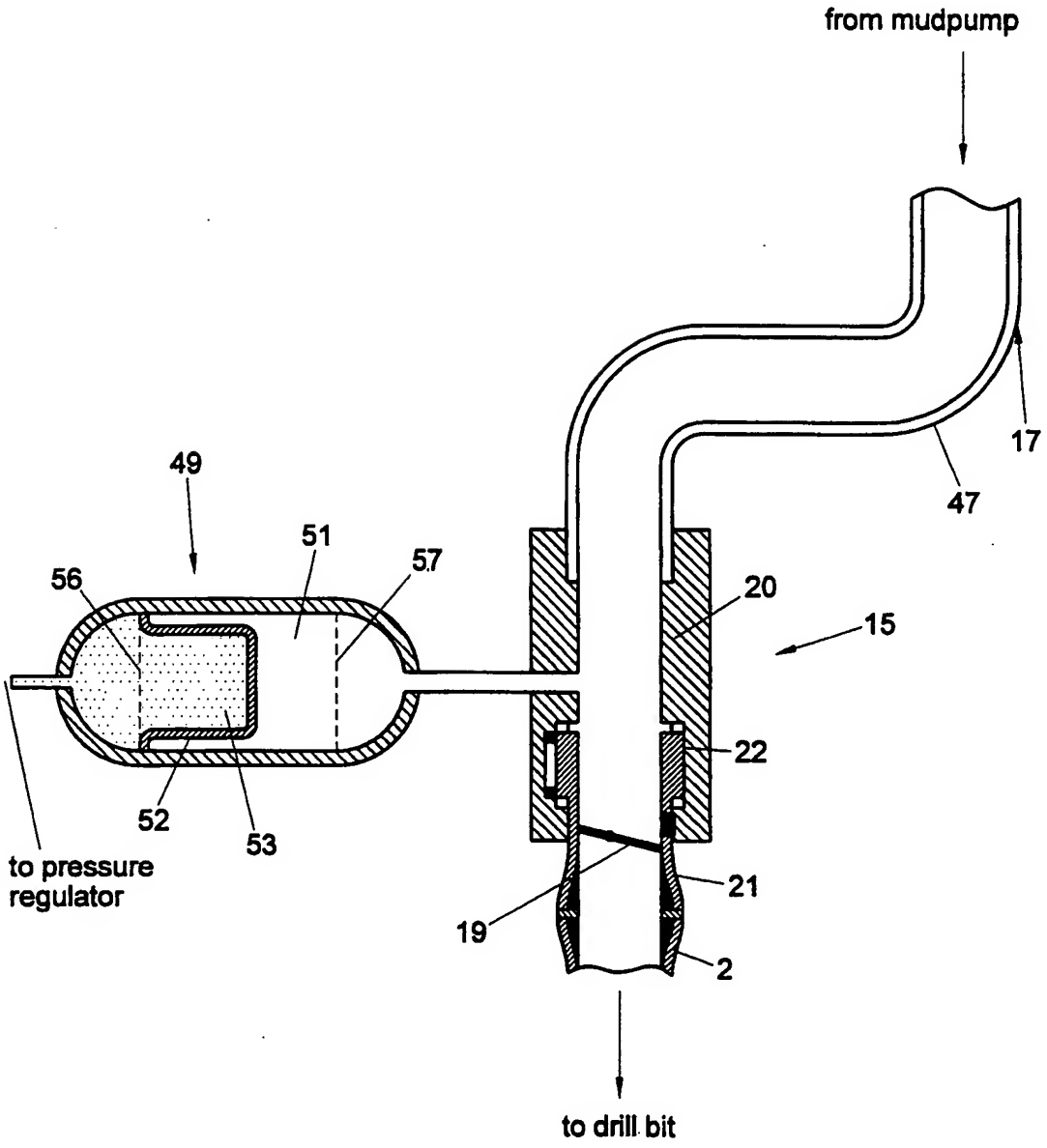
from mudpump
17
47
49
51
57
56
20
15
22
52
53
to pressure regulator
21
19
2
to drill bit

Fig. 8

INTERNATIONAL SEARCH REPORT

Inte onal Application No
PCT/NL 97/00726

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 E21B21/00

According to International Patent Classification(IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 E21B

Documentation searched other than minimumdocumentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 3 559 739 A (HUTCHISON STANLEY O) 2 February 1971 see column 1, line 14 - line 21 see claim 1; figure 2	6,9
A	---	1,2
X	US 4 315 553 A (STALLINGS JIMMIE L) 16 February 1982 see column 1, line 24 - line 30 see figure 1	6,9,12
A	---	1,2
A	EP 0 736 664 A (KLAUS OBERMANN GMBH) 9 October 1996 see column 2, line 11 - line 17	6,11

	-/--	

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"&" document member of the same patent family

Date of the actual completion of theinternational search	Date of mailing of the international search report
14 August 1998	24/08/1998

Name and mailing address of the ISA	Authorized officer
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INTERNATIONAL SEARCH REPORT

Inte nal Application No
PCT/NL 97/00726

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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INTERNATIONAL SEARCH REPORT

Information on patent family members

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PCT/NL 97/00726

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